THE EFFECT OF FOUR DIFFERENT CONDITIONERS ON THE SHEAR BOND STRENGTH OF COMPOSITE TO GLASS IONOMER – AN INVITRO STUDY

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In partial fulfillment of the degree of

MASTER OF DENTAL SURGERY

Branch IV

CONSERVATIVE DENTISTRY AND ENDODONTICS

2012 – 2015

CERTIFICATE

This is to certify that this dissertation titled **"The effect of four different conditioners on the shear bond strength of composite to glass ionomer – an in vitro study",** is a bonafide record of the work done **Dr. Rahul S** under our guidance during his / her post graduate study during the period of 2012-2015 under **THE TAMIL NADU DR. MGR MEDICAL UNIVERSITY, CHENNAI,** in partial fulfillment for the degree of **MASTER OF DENTAL SURGERY IN CONSERVATIVE DENTISTRY AND ENDODONTICS, BRANCH IV.** It has not been submitted (Partial or full) for the award of any other degree or diploma.

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ENDORSEMENT BY THE PRINCIPAL / HEAD OF THE INSTITUTION

This is to certify that the dissertation entitled **"THE EFFECT OF FOUR DIFFERENT CONDITIONERS ON THE SHEAR BOND STRENGTH OF COMPOSITE TO GLASS IONOMER – AN IN-VITRO STUDY"** is a bonafide research work done by **Dr. RAHUL S** under the guidance of **Dr RAJESH S,** MDS**,** Professor & HOD, Department of Conservative Dentistry and Endodontics, Sree Mookambika Institute of Dental Sciences, Kulasekharam.

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This is to certify that the research project protocol, ***Ref no: 05/03/2014*** entitled, ***"The effect of four different conditioners on the shear bond strength of composite to glass ionomer : An Invitro study "*** submitted by **Dr.Rahul .S** ***II Year MDS, Department of Conservative dentistry & Endodontics*** *has* been approved by the Institutional Research Committee at its meeting held on ***18th March 2014.***

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This is to certify that the Research Protocol Ref. No. **SMIMS/IHEC/2014/A/23,** entitled "The Effect of Four Different Conditioners on the Shear Bond Strength of Composite to Glass Ionomer: An *In Vitro* Study" submitted by Dr. Rahul S, Postgraduate of Department of Conservative Dentistry and Endodontics, SMIDS has been approved by the Institutional Human Ethics Committee at its meeting held on 6th of May 2014.

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CONTENTS

LIST OF ABBREVIATIONS

GIC	**-**	**Glass ionomer Cement**
RMGIC	**-**	**Resin Modified Glass Ionomer Cement**
MPa	**-**	**Mega Pascals**
SBS	**-**	**Shear Bond Strength**
PAA	**-**	**Polyacrylic acid**
TCA	**-**	**Trichloro Acetic Acid**
SEM	**-**	**Scanning Electron Microscope**
ANOVA	**-**	**Analysis of Variance**
SPSS	**-**	**Statistical package for Social Sciences**
kg/cm2	**-**	**Kilogram per Centimeter Square**
mm	**-**	**milli meter**
µm	**-**	**micro meter**
Er,cr:YSGG	**-**	**Erbium, Chromium doped Yttrium Scandium Gallium Garnet**
Fig.	**-**	**Figure**

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ABSTRACT

Introduction

The use of esthetic resin composites has increased over the past decades mainly due to the patient's esthetic concerns and improvements in the technology of products. With the advent of sandwich restorations the problems related to composites such as recurrent caries and post- operative sensitivity have drastically reduced. Studies have shown improvement in bond strength of composite to glass ionomer when conditioners were used on glass ionomer surface.

Aims and Objectives

This study was done to evaluate the effect of four different conditioners on the bond strength of composite to glass ionomer and to examine the resulting etched glass ionomer surface under Scanning Electron Microscope.

Methodology

Fifty glass ionomer discs were prepared in stainless steel moulds. It was divided into five groups of 10 moulds each out of which seven samples were tested for bond strength and remaining three samples were evaluated for scanning electron microscopic analysis. Group I is control without any surface treatment. Group II, III, IV and V were conditioned with 35% phosphoric acid, 10% polyacrylic acid, 10% citric acid and 35% trichloroacetic acid respectively. Adper single bond 2 was applied to all the specimens. Filtek Z350 XT light cure composite were place on the glass ionomer surface and light cured. All specimens were stored in deionized water for 24 hours at 37^0C before shear bond strength testing. The remaining three samples were

conditioned with four different conditioners, gold sputtered and examined under scanning electron microscope.

Results and Observations

The values obtained were tabulated and statistically analysed using ANOVA and Dunnett's test and it revealed significant differences in bond strength among groups. Significantly higher bond strength values were observed in group treated with 35% Phosporic acid followed by 10 % Polyacrylic acid, 10% Citric acid and 35% trichloroacetic acid when compared with group without any surface treatment. SEM observations revealed least salt crump formation in specimens treated with 35% phosphoric acid. Salt crump formation was greater in specimens treated with 35% trichloroacetic acid.

Conclusion

Under the limitations of this study it was found that the shear bond strength of composite reins to resin modified glass ionomer was increased following surface treatment.

Clinical significance

The use of conditioners will effectively improve the bonding between composite and glass ionomer.

INTRODUCTION

The use of direct posterior resin-based composite has dramatically increased over the past two decades primarily due to patients esthetic desires and product improvements. Other factors contributing to increased use of resin-based composite are environmental and health concerns with dental amalgam. The ability of resin composite to mimic natural tooth structure gave it a distinct advantage for patients and dental professionals over other materials. Resin-based composite consists mainly of a resin matrix surrounded by inorganic filler particles. Polymerization occurs through a free radical addition reaction. The double-bonded carbons of the methacrylate groups at each end of the active site on the monomer cross-links during the polymerization process, producing initially a linear polymer; then by reacting with the second site, a highly cross-linked polymer is produced.[1]

In contrast to the superior esthetics of resin-based composites stands their great constraint, which is their shrinkage associated with polymerization resulting in microleakage. Microleakage is defined as the clinically detectable passage of bacteria, fluids, molecules or ions between a cavity wall and the restorative materials applied to it and are a major problem in clinical dentistry. Shrinkage of the composite resin transfers stress to the cavity walls. Polymerization shrinkage can split the adhesive bond to the tooth or pull the opposing cusps together by deforming the tooth, resulting in fracture of marginal tooth structure, leading to microleakage, postoperative sensitivity, staining and recurrent caries[2].

In order to overcome this drawback sandwich technique was proposed by Mclean and Wilson in which glass ionomer cements are placed on dentin prior to the application of resin composite. Glass ionomer is an ideal dentin replacement material, because its coefficient of thermal expansion is very close to that of dentin. No other commonly used restorative material possesses this advantageous characteristic. In addition, the hydrophilic property of glass ionomers makes it well suited to bond and adapt to the dentin surfaces.[3]

Glass ionomer cements provide better retention and seal due to chemical bonding to the tooth structure reducing microleakage and marginal gap in non enamel margins.[4] Glass ionomer cements also has the ability to release fluoride ions, thereby decreasing the possibility of recurrent caries. Glass ionomers also adhere directly to, even humid, dental hard tissues.

The main drawback of conventional glass ionomer cement is its limited bond with the resin composite due to the low cohesive strength of the material and minimal chemical bonding between the two materials due to different chemical reaction. To overcome this drawback resin modified glass ionomer was used. The resin-modified glass ionomer cement show better aesthetic properties and is less technique sensitive and soluble compared to the conventional glass ionomer cement because of the resin content.[5]

In sandwich restorations the bond between glass ionomer and composite resin is one of the main factors in retention, durability and sealing of the restoration.[6] The bond between glass ionomer and composite resin is micromechanical bond.

The use of conditioners has shown to greatly improve the bond strength between composite and glass ionomer. Acid treatment of glass ionomer improves its bond to composite by producing a rough surface in which glass particles stand out above the matrix. Hence, the study hypothesis is that the application of conditioners on glass ionomer surface will enhance the bond strength of composite to glass ionomer in a sandwich restoration.

AIMS & OBJECTIVES

AIM

- To evaluate the effect of four different conditioners on the bond strength of composite to glass ionomer and to examine the resulting etched glass ionomer surface under Scanning Electron Microscope.

OBJECTIVE

- To evaluate the bond strength of composite to glass ionomer following the use of four different conditioners.
- To compare the resulting etched glass ionomer surfaces using scanning electron microscope.

REVIEW OF LITERATURE

Sneed et al 1985[7] in an in vitro study evaluated the shear bond strength of a composite resin bonded to an etched glass ionomer. Results indicate that shear bond strength between the two materials is greater than the cohesive strength of the glass ionomer itself. This property combined with other beneficial properties of glass ionomer materials may lead to their use as bases for composite resin restorations.

Hinoura et al 1987[8] in a study determined that etching or roughening the surface of glass ionomer cement before use of composite resins and bond agents produced bond strengths comparable to the bond strength between glass ionomers and dentin. Bond failure at such surfaces occurs within the glass ionomer. Adequate washing with water after acid etching the glass ionomer is essential to obtain optimal bond strength. Apparently, some combinations of ionomer cements and resins are more effective than are others in providing a good bond in the "sandwich technique".

Chin et al 1988[9] in an in vitro study determined the tensile bond strengths of three glass ionomer cements to dentine and the tensile bond strengths of composite to the three glass ionomers after etching. The tensile bond strength to untreated dentine was in the range of 4.47–5.52 MPa, being approximately twice that of a glass ionomer restorative material. After etching the glass ionomer, the bond strength to composite resin ranged from 1.83 MPa to 6.17 MPa, depending on the ionomer and on the time after mixing at which it was etched. In the majority of clinical situations, retention of

a composite restoration via etched glass ionomer cement would probably need to be supplemented by additional mechanical retention.

Wexler et al 1988[10] in a study evaluated the tensile bond strengths of a composite restorative material to phosphoric acid etched restorative glass ionomer cement were examined as a function of cement brand, time after mixing at which etching was performed, thickness of film on enamel and dentine and extent of exposure to water during cement maturation. Optimum bond strengths were obtained with mature cements isolated from water during maturation. Bond strengths were similar to or greater than tensile strengths of cements and many currently available dentine bonding agents for composites. Bonding to etched cement occurs by micromechanical interlocking and the zone of bond failure in tension was in the surface layer of the cement.

Subrata et al 1989[11] studied the effect of various surface treatments on the shear bond strength of composite resin to a glass-ionomer cement. Acid etching with phosphoric acid and polyacrylic acid, roughening by way of grinding or air drying, the use of a dentine bonding system and a silane coupling agent were the variables. Acid etching, grinding or air drying the surface of the cement had a significant effect on the bond strength. The use of a dentine bonding system led to a significant improvement in the resulting bonding. Silane coupling agent did not improve the bonding. Composite resin did not adhere to a smooth cement surface, but the

application of the dentine bonding system on such a surface produced a moderate bond.

Peutzfeldt et al 1989[12] assesed the tensile bond strength between etched glass-ionomer cement and composite resin, and also gap formation as assessed by wall-to-wall polymerization contraction and by microleakage with a silver nitrate technique. The influence of the following variables was examined: type of glass-ionomer cement and composite resin, duration of acid etching, irradiation time of unfilled and composite resin, preparation of bevel, conditioning with polyacrylic acid, and storing time in water before gap measurement. Glass-ionomer cement lining reduced wall-to-wall contraction and penetration of silver nitrate. A positive correlation was found between wall-to-wall contraction and silver nitrate penetration.

GJ Mount 1989[13] in a review paper discussed the result of testing a broad variety of combinations of different glass ionomer cements and composite resins that have been reported on previously, and suggests that a number of factors need to be taken into account if the optimum physical properties are to be achieved from the union. There would appear to be four main factors which dictate the final strength of the union. The tensile strength of the cement itself is of primary importance and it seems the wettability of the resin bonding agent is also significant. When using some of the less heavily filled composite resins, the stresses set up by the setting contraction of the resin may be too great and, finally, the more heavily filled composite resins for restoration of posterior teeth often prove difficult to adapt to the underlying cement.

Joynt et al 1989[14] in an invitro study examined the effects of etching time on surface morphology and adhesion of posterior composite resin to glass-ionomer cement. Three glass-ionomer cements and four etch times were studied. Bond shear strength results revealed significant differences by both cement and etch time. Glass-ionomer surfaces etched for 30 seconds produced the strongest bond to resin. Ketac-Silver cement provided greater shear resistance than either Ketac-Bond cement or GC lining cement. Scanning electron microscopy examination showed greater surface roughness for etched versus unetched glass ionomer. However, no subsurface differences were noted with increased etch times. These findings indicate that 30 seconds is the optimal etch time for glass-ionomer cement and that Ketac-Silver cement provides the strongest bond to resin of any of the materials tested. Etched glass-ionomer subsurfaces did not reveal marked differentiation in morphology, suggesting that an alternative method is necessary to detect these differences.

Tyas et al 1989[15] in an in vitro study restored hundred and thirty-eight non-undercut Class V abrasion lesions using glass ionomer cement overlaid by composite resin. Four techniques were used: enamel and glass ionomer acid-etched, enamel only acid-etched, ionomer only acid-etched, and neither enamel nor glass ionomer acid-etched. The restorations were examined after six months, one year and two years and evaluated for integrity and marginal staining, the latter employing a direct clinical method and a set of photographic standards. The relative failure of restorations at six months was maintained at subsequent time intervals, and at two years the failure

incidence was 10, 35, 43 and 58 per cent for the above four techniques respectively. Marginal staining was most evident around those restorations for which only the glass ionomer had been etched. The results indicate that the retention of composite to etched glass ionomer is similar to that of composite to dentine using many dentine bonding agents.

Sheth et al 1989[16] has conducted a two-part study to evaluate the tensile bond strengths of composite resin to several glass-ionomer cements that were (a) unetched but allowed to set in air and (b) etched for 30 s with orthophosphoric acid, and to compare them with the cohesive strength of the respective cement. Using a silver nitrate staining technique, they also evaluated the microleakage of class V cavities restored with composite resin under a base of etched or unetched glass ionbomer cement. Although there were significant differences among three cements between their cohesive strength and the resin bond strength after the two surface treatments, the bond to the unetched surface was generally comparable to that of the etched surface of the cement. The remaining groups showed no statistical difference. The microleakage was similar in the two groups. SEM micrographs showed a rough topography of the unetched cement that resembled that of the etched surface. This in vitro study suggests that acid-etching a glass-ionomer base for resin-bonding may not be necessary for specific materials.

Mangum et al 1990[17] in an in vitro study compared the bond strength of a composite resin to glass ionomer cement with two types of surfaces and four etching

times and attempted to correlate the bond strengths with a scanning electron microscope (SEM). The bond strengths were significantly greater to the instrumented surface at all etching times and the composite resin would not bond to glass smooth, unetched glass ionomer.

Papagiannoulis et al 1990[18] assessed the surface alterations induced by acid etching on two glass ionomer lining cements and to evaluate their interface with a composite resin following various surface treatments. According to the results the etched surfaces of both the liners present excessive porosity with glass and matrix dissolution. Significant changes in the surface chemistry of the liners were detected indicating severe degradation. The microleakage study revealed interfacial gaps and fractures in the etched samples. The best results were obtained from the non-etched ionomer liners which were subjected to the adhesive treatment.

Fuss et al 1990[19] in view of the continuing interest in the use of glass ionomer cements as a dentine substitute or base under composite resins, further investigations were carried out on the effects of the length of time of etching of the surface of the cement prior to the placement of the resin. A number of cements are available on the Australian market which are advocated for use in this technique. Each of them was subjected to etching for periods of 15, 30, 45, or 60 seconds and then stored in water for one week. Examination under a dissecting microscope and a scanning electron microscope revealed some variation in results between the different cements. While 15 seconds is the preferred time for most cement, some require times up to 60 seconds

to achieve the best result. Also, some of the cements showed signs of cracking, expansion and distortion after they had been stored in water for one week to allow for maturation before being prepared for viewing under the SEM. It is suggested that this group of cements is not suitable for the 'sandwich' technique.

Hinoura et al 1991[20] in an invitro study investigated the bond strength of various composite resins and their bond agents to unetched glass ionomer. The pH of the bond agents was measured and related as bond strength. The influence of time elapsed between mixing the glass-ionomer cement and placement of the bond agent was also studied. Bond strengths varied from 65.5 kg/cm2 for G-C Dentin Cement with Pyrofil Light Bond A to 3.2 kg/cm2 for G-C Dentin Cement with Bis-Fil-M. The pH range was from 2.28 for Pyrofil Light Bond to 7.62 for Durafill Bond. Low correlation coefficients between bond strength values and pH indicated only limited relationship between the two. The bond strength decreased as the time lapse between the end of the mix and application of the bond agent increased.

Taggart et al 1991[21] in an in vitro study investigated the effect of acid etching on the surface appearance and flexural strength of four glass polyalkenoate cements. Specimens were etched for intervals of 10–60 seconds, both at the recommended time after mixing and after a 24-hour delay. The surface texture was examined microscopically. Further specimens were subjected to a 4-point bend test following etching 1 hour and 24 hour after mixing. Deterioration of the surface appearance occurred as the etching time was increased beyond 10 seconds following

immediate etching. Etching after 24 hours reduced surface damage, but a 10 second etch still gave the most favourable surface appearance without loss of particulate material. Etching beyond 10 seconds significantly reduced the flexural strength.

Chadwick et al 1993[22] examined the shear bond strengths of P-50 resin composite to four glass polyalkenoate lining materials, with and without the application of an intermediate bonding agent (Scotchbond 2). Two of the cements were RMCs (Vitrebond, XR-Ionomer) and the others were conventional base materials (Baseline, Ketac-Bond). The bond between P-50 and Vitrebond with or without Scotchbond 2 was significantly stronger and more consistent than that observed for all other materials. The treatment of the conventional materials and XR-Ionomer with Scotchbond 2 significantly improved the bond strengths to P-50. They concluded that Vitrebond formed the most favourable cement-resin composite bond and that the other materials studied should be used in conjunction with an effective intermediate bonding agent, such as Scotchbond 2.

Amin et al 1994[23] in an invitro study assessed the shear bond strengths between a visible light cure resin composite and different surface treatments of glass-ionomer cement were estimated in the dry and wet conditions. They established that that group (V), where saline coupling agent was applied to the non-etched glass-ionomer cement surface, followed by the application of bonding agent, showed maximum bond strength. On the other hand, group (II) where composite resin was packed directly on the etched glass-ionomer surface showed the least bond strength.

Moreover, the wet storage of the different groups elicited a varying percentage of reduction in the shear bond strength values.

Fortin et al 1995[24] evaluated the bonding between resin composites and resin-modified glass ionomer restorative materials. They concluded that the type of composite used had no significant effect on transverse strength. However, the type of resin-modified glass ionomer used was significant. Although there was much overlap between materials, bonded specimens made with Fuji II LC had the highest absolute strength, and those made with Photac-Fil had the lowest absolute strength. Bonded Vitremer specimens had the highest transverse strength relative relative to the cohesive strength of the material.

Tate et al 1996[25] in an invitro study compared the tensile bond strength between three hybrid ionomers and two composites. They concluded that etching the hybrid ionomers with phosphoric acid had no statistical effect on bond strength.

Aboushala et al 1996[26] in an in vitro study undertaken microleakage studies for Class II composite resin restorations that had been lined with glass-ionomer cement using the 'sandwich' technique. They concluded that the application of a light-cured glass-ionomer up to the cavo surface margin inhibits the microleakage of Class II restorations.

Zanata et al 1997[27] in an vitro study evaluated the effect of etching resin-modified and conventional glass ionomer cements prior to the application of a

bonding agent on the shear bond strength at the glass ionomer cement/composite resin interface. They concluded that the resin-modified glass ionomer cements reached higher shear bond strengths than the conventional materials. The GC Fuji Lining LC and Vitrebond cements showed superior bond strengths than all the other materials tested. The conventional cement Ketac Bond Aplicap and the resin-modified cement Photac-Bond were not statistically different and showed intermediary values. The conventional cements Ketac-Bond and GC Lining Cement showed the lowest shear bond strength rates and were inferior to the resin-modified cements.

Farah et al 1998[28] compared the use of self cured and resin modified glass ionomer cement on the bond strength to composite and found that resin modified glass ionomer cement showed true adhesive bond to resin composites

Mesquita 1999[29] in an in vitro study evaluated the effect of storage time and acid etching on the tensile bond strength of glass ionomer cement to composite resins. They concluded that best tensile bond strength was obtained without acid etching. Acid etching causes severe surface degradation for this type of cement resulting in poor tensile bond strength. Results obtained for Vidrion F were higher than those for Ketac Bond, which may be due to the cement conditions prior to acid etching, cohesive strength and particle size, all of which may affect bond strength. They suggested that acid etching not to be used when glass ionomer cement is used as a lining base for composite resins.

Van Dijken et al 1999[49] in an in vitro study evaluated the durability and cariostatic effect of a modified open-sandwich restoration utilizing resin-modified glass-ionomer cement in large cavities. According to them three-year results indicated that the modified open-sandwich restoration is an appropriate alternative to amalgam including extensive restorations

Burgess et al 2002[30] in a review article described the use of Resin-based composite for restoring defects in posterior teeth. They summarized that proper application of resin based composite in posterior cavity preparations requires knowledge of adhesives, composites, polymerization kinetics, and the ability to apply those principles to the patient being treated.

Berg JH 2002[51] in a review article described the use of glass ionomer cements as sealants and restorative material and also examined its use as adhesives in sandwich restorations.

Yamamoto et al 2003[54] in an invitro study evaluated the effects of tooth conditioning agents on bond strength of resin modified glass ionomer sealant to enamel. They concluded that the use of tooth conditioning agents has greatly improved the bond strength of glass ionomer to bovine enamel.

Karthik et al 2004[55] in an invitro study determined the duration of light activation on glass ionomer cement and its effect on the bond strength to resin

composite. They came to the conclusion that the shear bond strength was increased when it is light activated for 40 seconds.

Knight et al 2006[31] in an in vitro study evaluated the bond strength between co cure RMGIC and resin composite. They concluded that co-cured RMGIC bonding system produced a significantly stronger chemical bond between GIC and composite resin than the etch and bond technique

Taher et al 2007[32] in an in vitro study determined the shear bond strength and the type of bond failure when resin modified glass ionomer cement was bonded with different tooth colored restorative materials. They concluded that a chemical bond exist between RMGIC and tooth colored restorative materials.

Bona et al 2007[33] in an invitro study evaluated the sealing ability of different glass ionomer cements used for sandwich restorations and assessed the effect of acid etching of GIC on microleakage at GIC-resin composite interface. They came to the conclusion that phosphoric acid etching of GIC prior to the placement of composite resin does not improve the sealing ability of sandwich restorations. Also the resin modified glass ionomer was more effective in preventing dye penetration at the GIC-resin composite dentin interface than conventional glass ionomer.

Gopikrishna et al 2009[34] in an in vitro study evaluated the bond strength of resin composite to glass ionomer cement using three different bonding systems. They

concluded that the bond strength of composite to GIC was higher for self etch primer group on unset GIC compared to GIC based adhesive on set GIC

Arora et al 2010[35] in an in vitro study evaluated and compared the role of newer dental adhesives to bond composite resin to the resin modified glass ionomer liner. They concluded that application of Self-Etch adhesive in between RMGIC and composite resin increased the shear bond strength between RMGIC and the resin composites, as compared to the Total-etch type adhesives, as well as, without application of the adhesive agent.

Maruo et al 2010[36] examined the influence of etching and light-curing time on the shear bond strength (SBS) and adhesive remnant index (ARI) of resin-modified glass ionomer cement (RMGIC) upon debonding of orthodontic brackets. Shear bond strength of RMGIC was enhanced with 37% phosphoric acid etching and 40 s light-curing time, but this did not occur when the light-curing time was increased, regardless of the acid used. RMGIC presented prevalence of failures at the adhesive/bracket interface.

Khoroushi et al 2010[37] in an in vitro study evaluated the effect of TCA gel in its use before etchant on the shear bond strength between resin composite and enamel and also its effect on the enamel surface morphological characteristics. They concluded that application of TCA to enamel prior to conventional etching in tooth

colored cervical restorations have a positive effect on the immediate bond strength of resin composite to enamel.

Navimipour et al 2011[38] in an invitro study compared the influence of 35% phosphoric acid and Er, cr:YSGG laser on shear bond strength of conventional glass ionomer cement and resin modified glass ionomer cement to resin composite. They concluded that surface conditioning with phosphoric acid or Er,cr:YSGG laser showed increase in shear bond strength of GIC to composite resin for conventional glass ionomer, however for RMGIC only laser treatment resulted in increased bond strength.

Ismail et al 2012[39] in an in vitro study compared the shear bond strength of chemically cured (Conventional) glass ionomer cement and light cured (Resin modified) glass ionomer cement to resin composite and also evaluated the effect of acid etching of the glass ionomer cements on the shear bond strength. They concluded that RMGIC had better shear bond strength to resin composite than conventional GIC. Also the acid etching of GIC prior to placement of bonding agent and resin composite in sandwich restoration did not improve the shear bond strength of GIC to resin composite.

Kandaswamy et al 2012[40] in an invitro study investigated the bonding ability of composite to unset glass ionomer using various self etch bonding systems. The results proved that the use of mild etch bonding agent over unset glass ionomer

cement has increased bond strength when compared with strong and intermediate self etch bonding agent.

Pamir et al 2012[41] in an invitro study determined the effects of various surface treatment modalities on the bond strength of composite resins to glass-ionomer cements. They concluded that the bond strength of the composite resin to the conventional glass-ionomer cement was considered significantly lower than that to the resin-modified glass-ionomer cement. No significant differences were determined between the self-etching and etch-rinse & bond adhesives at any etching time. However, greater bond strength was obtained when phosphoric acid was applied for 30 seconds.

Mitra et al 2012[42] in an invitro study evaluated the tensile bond strength of composite resin to etched and unetched glass ionomer cement. They concluded that both the types of composite resin did not show any significant difference in bond strength to Glass Ionomer cement, whether etched or unetched.

Kimyai et al 2012[43] in an invitro study evaluated the effect of three surface treatments of conventional glass-ionomer on its shear bond strength to giomer. They came to the conclusion that shear bond strength of glass-ionomer to giomer depends on surface preparation. Etching the surface of set glass-ionomer with a total-etch system or placement of self-etch adhesive on the surface of glass-ionomer with

incomplete initial setting resulted in compromised bonding of giomer to glass-ionomer.

Chandak et al 2012[47] in an in vitro study evaluated the shear bond strength of resin modified glass ionomer to composite resin using different adhesive systems.They concluded that application of self etch adhesive increased the shear bond strength between resin modified glass ionomer and composite as compared to total etch type adhesive and without application of adhesive agent

Kasraie et al 2013[44] in an in vitro study compared the micro shear bond strength between composite and RMGIC by a self-etch adhesive system.They concluded that application of bonding systems results in an increase in micro shear bond strength between RMGIC and light cured composites when compared to group with no bonding agent. Application of self etch systems resulted in a greater increase in micro shear bond strength between RMGIC and light cured composite resin compared with the use of etch and rinse systems. The highest micro-shear bond strength between RMGIC and light cured composite resin was achieved with the use of two step self etch primer System.

Otsuka et al 2013[45] in an in vitro study evaluated the influence of surface treatment of glass ionomer on bond strength of resin composite.They concluded that surface treatment of conventional GIC promoted higher bond strength to resin composite but decreased bond strength for RMGIC.

Bortoletto et al 2013[46] the influence of dental etching on the shear strength of different glass ionomer cements. They concluded that pre-etching increased the shear strength of Riva glass ionomer cement (SDI) alone, whereas no statistically significant differences were found with regard to the other materials tested. Pre-etching with 10% polyacrylic acid for 30 seconds increased the shear strength of Riva glass ionomer cement.

Arora et al 2013[48] in a review article evaluated the open sandwich technique in which a glass ionomer cement or RMGIC was placed between the dentin gingival margins and occlusal composite restorations. These restorations are less technique sensitive than composite restorations and high degree of gap free adaptation to dentin.

Nuttall et al 2013[50] in an invitro study evaluated the shear bond strength of a resin-modified glass ionomer (RMGI) restorative material to a new silorane-based composite and a methacrylate-based composite in a sandwich restoration with various combinations of surface treatments and bonding agents. They concluded that the new silorane composite had significantly lower bond strength to the RMGI compared to the methacrylate composite. The new silorane system adhesive agent had significantly higher bond strength to the RMGI compared to the methacrylate adhesive agent. The greatest bond strengths to the RMGI were produced when using the silorane system adhesive agent with the methacrylate composite.

Boruziniat et al 2014[52] in an invitro study evaluated the bond strength between RMGIC and composite using different adhesive systems and curing techniques. They concluded that the applications of self etch adhesive systems and co cure technique had improved the bond strength between RMGIC and composite.

MATERIALS & METHODS

Materials used in the study

a) 35% Phosphoric acid (Scotchbond Multi-Purpose Etchant, 3M ESPE, St Paul, MN, USA)

b) 10% Polyacrylic acid (GC Dentin conditioner, GC Corporation, Tokyo, Japan)

c) 10% Citric acid (Spectrum Reagents and Chemicals Pvt Ltd , Kochi India)

d) 35% Trichloroacetic acid (Spectrum Reagents and Chemicals Pvt Ltd , Kochi, India)

e) GC Fuji II LC Capsule (Radiopaque Light cured Reinforced Glass ionomer restorative, GC Corporation, Tokyo, Japan)

f) Adper single bond 2 (3M ESPE, Dental Products, St Paul, MN, USA)

g) Resin composite (Filtek Z350 XT, 3M ESPE, Dental products, St.Paul, MN, USA)

h) Distilled water (Nice chemicals Pvt Ltd, Kochi, India)

i) Stainless steel ring (Dentaurum Australia Pty Ltd, Mortlake, NSW)

j) 200, 400, 600 grit silicon carbide paper (Moyco Precision Abrasives, Montgomeryville, PA, USA)

k) Acrylic resin (Asian acrylates, Mumbai, India)

Equipments Used in the study

a) Composite light curing unit - DENTSPLY, Milford, Detroit, USA

b) Amalgamator (SYG 200) Hangzhou Sifang Medical Apparatus Co., Ltd, Zhejiang, China

c) Universal Testing Machine- Model 3345; Instron corp, Canton, Mass, USA

d) Gold Sputtering Machine-No E-1010 Ion sputter, Hitachi, Japan

e) Scanning electron microscope-No S-2400, Scanning electron microscope Hitachi, Japan

METHODOLOGY

Specimen preparation

A total of 50 Glass ionomer discs were prepared using stainless steel molds, 6mm in diameter and 4mm in thickness. The stainless steel molds were prepared from stainless steel orthodontic bands (Dentaurum Australia Pty Ltd). The molds were filled with GC Fuji II LC (GC corporation, Tokyo, Japan), which was mixed according to the manufacturer's instructions in an amalgamator (Hangzhou Sifang Medical Apparatus Co., Ltd , Zhejiang, China) for 2 seconds. The surface of the filled molds was pressed with a glass slab and light cured for 60 seconds with a light curing

unit (DENTSPLY, Milford, Detroit, USA) of intensity 500mw/sec. The discs were polished with 200,400 and 600 grit carbide polishing papers (Moyco Precision Abrasives, Montgomeryville, PA, USA) and were randomly divided into five groups of 10 molds, out of which 7 molds were used for testing of bond strength and 3 molds for Scanning electron microscope analysis.

The various conditioners used in the study were 35% Phosphoric acid, 10% Polyacrylic acid, 10% Citric acid and 35% Trichloro acetic acid.

Preparation of conditioners

10 grams of citric acid powder (Spectrum reagents) was dissolved in 100 ml of distilled water to make 10% citric acid solution.

35 grams of acetic acid powder (Spectrum reagents) was dissolved in 100 ml of distilled water to make 35% trichloro acetic acid solution.

Conditioning Protocol and Composite placement

Group I was the control therefore no conditioner was used. In the seven specimens of group I, Adper single bond 2 (3M ESPE, Dental Products, St.Paul, MN, USA) was applied to the surface and light cured according to manufacturer's instructions. Stainless steel mold measuring 4 mm in internal diameter and 2 mm in height was placed on the disc surface and Filtek Z350 XT light cured composite resin (Filtek Z350 XT, 3M ESPE, Dental products, St.Paul, MN, USA) was carefully

placed inside the molds and light cured for 40 seconds using light curing unit (DENTSPLY, Milford, Detroit ,USA)

Group II: In seven specimens, 35% Phosphoric acid (Scotchbond Multi-Purpose Etchant, 3M ESPE, St Paul, MN, USA) was used as conditioner on glass ionomer for 20 sec and rinsed with distilled water. Then Adper single bond 2 (3M ESPE) was applied to the surface and light cured according to manufacturer's instructions. After which stainless steel molds measuring 4 mm in internal diameter and 2 mm in height was placed on the disc surface and Filtek Z350 XT light cured composite resin was carefully placed inside the molds and light cured for 40 seconds using light curing unit (DENTSPLY, Milford, Detroit, USA).

Group III: In seven specimens, 10 % polyacrylic acid (GC Dentin conditioner, GC Corporation, Tokyo, Japan) was used as conditioner for 20 sec and rinsed with distilled water. Then Adper single bond 2(3M ESPE) was applied to the surface and light cured according to manufacturer's instructions. After which cylindrical stainless steel molds measuring 4 mm in internal diameter and 2 mm in height was placed on the disc surface and Filtek Z350 XT light cured composite resin was carefully placed inside the molds and light cured for 40 seconds using light curing unit. (DENTSPLY, Milford, Detroit, USA)

Group IV: In seven specimens, 10% citric acid (Spectrum Reagents) was used as conditioner for 20 seconds and rinsed with distilled water. Then Adper single bond

2 (3M ESPE) was applied to the surface and light cured according to manufacturer's instructions. After which cylindrical stainless steel molds measuring 4 mm in internal diameter and 2 mm in height was placed on the disc surface and Filtek Z350 XT light cured composite resin was carefully placed inside the molds and light cured for 40 seconds using light curing unit (DENTSPLY, Milford, Detroit, USA).

Group V: In seven specimens, 35% trichloroacetic acid (Spectrum Reagents) was used as conditioner for 20 seconds and rinsed with distilled water. Then Adper single bond 2 (3M ESPE) was applied to the surface and light cured according to manufacturer's instructions. After which cylindrical stainless steel molds (4mm internal diameter and 2mm height) was placed on the disc surface and Filtek Z350 XT light cure composite was carefully placed inside the molds and light cured for 40 seconds using light curing unit (DENTSPLY, Milford, Detroit, USA).

Group I (control): Glass Ionomer without pretreatment + Composite

Group II: Glass Ionomer + 10% Polyacrylic acid + Composite

Group III: Glass Ionomer + 35% Phosphoric acid + Composite

Group IV: Glass Ionomer + 10% Citric acid + Composite

Group V: Glass Ionomer + 35% Trichloroacetic acid + Composite

SHEAR BOND STRENGTH TESTING

The seven specimens of each of the five groups were stored in distilled water for 24 hours at 37^{o}C. In order to measure shear bond strength, the specimens were placed in between the jigs of the universal testing machine and a pointed shearing rod was placed on to the composite resin/glass ionomer interface and was subjected to static loading at a rate of 1mm/min. The machine was interfaced with a computer through which operation was controlled and shear bond strength was calculated. Maximum load at failure was recorded in kilo Newton (KN). The shear bond strength (SBS) in mega Pascals (MPa) was calculated by the formula SBS=F (N)/πr^2, where F is force in newton and r is the radius of the prepared composite resin block.

The values obtained were tabulated and statistically analysed using computer software, Statistical Package for Social Sciences (SPSS) version 16.0. Data was expressed in its mean and standard deviation. Analysis of variance (One way ANOVA) was performed as parametric test to compare different variables. To elucidate multiple comparisons between groups, Dunnett test with ANOVA 16.0 as post hoc test. For all statistical evaluations, a two-tailed probability of value, <0.05 was considered significant.

SEM analysis of etch pattern

Scanning electron microscope was used to visualize the effect on glass ionomer surface of the various surface treatments used in the bonding study. The surfaces of the remaining three glass ionomer disc of each group were conditioned with four different conditioners.

Group II (a) - 20 sec application of 35% phosphoric acid rinsed with distilled water and air dried

Group III (a) - 20 sec application of 10% polyarcylic acid, rinsed with distilled water and air dried

Group IV (a) - 20 sec application of 10% citric acid, rinsed with distilled water and air dried

Group V (a) - 20 sec application of 35% trichloroacetic acid, rinsed with distilled water and air dried.

All specimens were gold sputtered and analyzed by Scanning Electron Microscope.

RESULTS & OBSERVATIONS

Tables I-V Shows the shear bond strength values of all the samples in their respective groups in megapascals (Mpa) calculated by the formulae SBS = F (N)/$\pi r^{2.}$

Table- I Shows the shear bond strength values in MPa obtained for each sample which was bonded to composite without any surface treatment.

Table -II Shows the shear bond strength values in MPa obtained for each samples which were bonded to composite following conditioning with 35% Phosphoric acid.

Table - III Shows the shear bond strength values in MPa obtained for each samples which were bonded to composite following conditioning with 10 % Polyacrylic acid.

Table - IV Shows the shear bond strength values in MPa obtained for each samples which were bonded to composite following conditioning with 10% citric acid.

Table - V shows the shear bond strength values in MPa obtained for each samples which were bonded to composite following conditioning with 35% Trichloroacetic acid.

Table –VI shows the mean shear bond strength values of different groups.

Table VII- shows the multiple comparisons of mean shear bond strength (MPa) values between the different groups.

As evident from statistical analysis high bond strength values were obtained with Group II, the phosphoric acid etched group. Least bond strength values were observed in group I which was the control.

Group II specimens which were conditioned with 35% phosphoric acid showed a mean bond strength value of 10.68MPa which is statistically significant than that of group I, group IV and group V. Group II specimens showed slight increase in bond strength value than that of group III (9.10 MPa) but were not statistically significant.

Group III specimens which were conditioned with 10% Polyacrylic acid showed a mean bond strength value of 9.10 MPa which were statistically significant than that of group I, group IV and group V. Group III specimens showed no significant difference with group II.

Group IV specimens which were conditioned with 10% citric acid showed a mean bond strength value of 7.19MPa which were statistically significant with group I, group II, group III and group V.

Group V specimens which were conditioned with 35% trichloroacetic acid showed a mean bond strength value of 5.78MPa which were statistically significant with group II, group III and group IV.

SEM ANALYSIS

Specimens of groups II, III, IV and V were analysed by scanning electron microscopy and following were the observations:

Figure 9 (Group II a) – Photomicrographs of 35% phosphoric acid treated specimens showing the least salt crumps formation.

Figure 10 (Group III a) - Photomicrograph of 10% polyacrylic acid treated specimens with salt crumps formation greater than group II a i.e. 35% phosphoric acid treated specimens.

Figure 11 (Group IV a)-Photomicrograph of 10% citric acid treated specimens with more salt crumps than both Group II a and Group III a i.e. 35% phosphoric acid and 10% polyacrylic acid treated specimens.

Figure 12 (Group V a) - Photomicrograph of 35% Trichloroacetic acid treated specimens with maximum salt crump formation compared to Groups II a, III a, IV a.

TABLES

Table-1: Shear bond strength values of group I in MPa

S. No	Group-I
1	4.62
2	4.02
3	3.81
4	3.60
5	4.83
6	4.98
7	4.11
MEAN±SD	**4.28±0.53**

Table- 2: Shear bond strength values of group II in Mpa

S.No	Group II
1	9.10
2	11.67
3	11.03
4	11.42
5	10.99
6	10.88
7	9.65
MEAN±SD	**10.68±0.94**

Table- 3: Shear bond strength values of group III in Mpa

S.No	Group III
1	9.16
2	8.48
3	9.12
4	9.59
5	9.46
6	9.53
7	8.39
MEAN±SD	**9.10±0.43**

Table- 4: Shear bond strength values of group IV in Mpa

S.No	Group IV
1	7.09
2	6.85
3	5.49
4	7.94
5	7.64
6	7.66
7	7.68
MEAN±SD	**7.19±0.84**

Table- 5: Shear bond strength values of group V in Mpa

S.No	Group V
1	6.09
2	5.64
3	6.09
4	6.02
5	5.69
6	5.05
7	5.93
MEAN±SD	**5.78±0.37**

Table-6: Mean Shear bong strength (MPa) values of different groups

Groups	Type of etching	Shear Bond Strength (MPa) (MEAN±SD)
Group-I	Control group (without any surface treatment)	4.28±0.53
Group-II	35% Phosphoric acid	10.68±0.94
Group-III	10 % Polyacrylic acid	9.10±0.43
Group-IV	10% Citric acid	7.19±0.84
Group-V	35% Trichloro acetic acid	5.78±0.37

Table-7: Multiple comparisons of mean shear bond (MPa) values between the different groups

Groups	Type of irrigation	Shear Bond Strength (MPa) (MEAN±SD)
Group-I	Control group (without any surface treatment)	4.28±0.53
Group-II	35% Phosphoric acid	10.68±0.94*
Group-III	10 % Polyacrylic acid	9.10±0.49*
Group-IV	10% Citric acid	7.19±0.84*,#,$
Group-V	35% Trichloro acetic acid	5.78±0.37*,#,$, ‖

(*P<0.05 significant compared group-I with II, III, IV and V, #P<0.05 significant compared group-II with I, IV and V, $P<0.05 significant compared group-III with I, IV and V, ‖P<0.05 significant compared group-IV with I, II, III and IV, P<0.05 no significant difference between the group-II compared with group-III).

DISCUSSION

In this study it was observed that the application of all the four surface conditioners to glass ionomer in sandwich restorations improved the bond strength. This proves our hypothesis that surface conditioning enhances the bond strength of Resin modified GIC to composite.

There is a continuous desire for novelties in dentistry originating from changing professional perceptions, changing demands from the patient and progress in industrial potentials. Today's dentistry can be characterized by a shift from metallic to non-metallic restorations. The patient attitude to treatment is mainly based on concern for aesthetics and biocompatibility. In direct restorative dentistry this correlates with a shift from traditional amalgam restorations to aesthetic composite restorations.[56]

The resin composites were used to replace the missing tooth structure and modify tooth colour and contour thus enhancing the aesthetic appearance of the individual. Before the advent of composites, silicates were the first aesthetic direct restorative material used. Although silicates provided an anti-cariogenic effect its use has subsided due to its early clinical failure which was related to its dissolution in oral fluids, loss of translucency, surface crazing and lack of adequate mechanical properties. The use of acrylic resins which were unfilled has also declined due to its

lack of reinforcement potential. Another drawback of unfilled resins is its dimensional instability leading to unsightly stains and recurrent caries.[57]

The traditional methacrylate based composites were first developed in mid 1960 as a replacement for silicate cements and unfilled resins. Since then these materials had greatly improved in its properties and handling characteristics and now it is considered as the primary restorative material. Over the years properties such as lack of color stability and wear resistance of these materials are improved due to changes made to the initiator, introduction of microfillers and hybridization of manufacturing process.[50]

In order to overcome the drawbacks of traditional composites, such as surface roughness and low translucency microfilled composites was introduced in which colloidal silica particles are added as inorganic filler. The microfilled composites also had their disadvantages mainly polymerization shrinkage, water sorption and thermal expansion. [60]

Hybrid composites were developed in an effort to obtain a smooth surface provided by microfilled composites while maintaining the properties of small particle composites. There are two kinds of filler particles colloidal silica and ground glass with an average particle size of 0.6-1.0μm. They have the advantage of good strength

over microfilled composite, but their surface smoothness and translucency are inferior to microfilled composite resins. [60]

To overcome the drawback of microfilled and hybrid composites, nano composites were introduced which showed aesthetic properties similar to those of microfilled composite while maintaining physical properties equivalent to those of hybrid composites. This allows the clinician to use them for restoring both anterior and posterior teeth. Nano composites have improved mechanical properties such as compressive and tensile strength, higher fracture and wear resistance, reduced polymerization shrinkage, high translucency, high polishability, retention and better aesthetics.[60] Hence in this study Filtek Z 350 XT nano composite was used.

Various improvements in mechanical properties of composite resins and aesthetic need lead to an increased application of these materials by the clinicians. Composite resins have undergone improvement in all areas, including aesthetics, wear, and handling. However, high-polymerization shrinkage continues to be a major disadvantage. Previous studies have shown polymerization shrinkage leading to bond failure and micro-leakage of resin composite restorations. Micro-leakage is a matter of concern because it leads to staining at the margins of restorations, recurrent caries, hypersensitivity, and pulp pathology.[12]Another main drawback of composite is its weak bonding to the dentin mainly in gingival floor of cavities.[44]

In order to overcome these drawbacks sandwich restoration was introduced. The concept of this technique is to use two types of materials to form one restoration. This technique made use of the chemical adhesion and fluoride release property of glass ionomer and aesthetics and polishability of composite resins.[40] The main advantage of this technique is the adhesive property of glass ionomer which make it an ideal restorative material for non carious cervical lesions. Another advantage of sandwich technique is the fluoride releasing property of GICs, which has an inhibitory effect on formation and progression of caries around the restoration.[33]

The bond strength between glass ionomer and composite is dependent on following factors:

i) The tensile bond strength of glass ionomer cement

ii) Viscosity of bonding agent and ability to wet the surface of GIC

iii) Volumetric change in composite resin during polymerization

iv) Packing and adaptation of composite resin to glass ionomer without any entrapment of voids.

v) Surface treatments used[13]

The drawback of conventional glass ionomer is its sensitivity to moisture and low initial mechanical strength. Previous studies have shown that conventional glass

ionomer does not effectively seal the dentin which is mainly attributed to dehydration after setting leading to crazing and cracking.[55]

The main advantage of resin modified glass ionomer over conventional glass ionomer cement is that it sets by an acid base reaction and exhibits command set when activated by light via methacrylate group.[35] Ismail et al in a study has shown better bond strength of resin modified glass ionomer to composite resin than conventional glass ionomer. Resin modified glass ionomer and resin composite are polymerized by a free radical initiator system which is necessary for chemical bonding between the two materials.[39] The presence of hydroxyethyl methacrylate on the glass ionomer surface enhances the surface wetting of bonding agent resulting in increased bond strength.[28]

Several criterias are thought to be involved in the chemical adhesive bond between resin modified glass ionomers and composite resins. Increased availability of unsaturated double bonds in air inhibited layer of resin modified glass ionomer cement may assist in chemical bonding to the resin bonding agent and resin composite.[28]

Resin modified glass ionomer capsules were used in this study and was mixed according to the manufacturer's instructions in a standard amalgamator. Studies have proved that voids and porosities are present in both hand and machine mixed cements

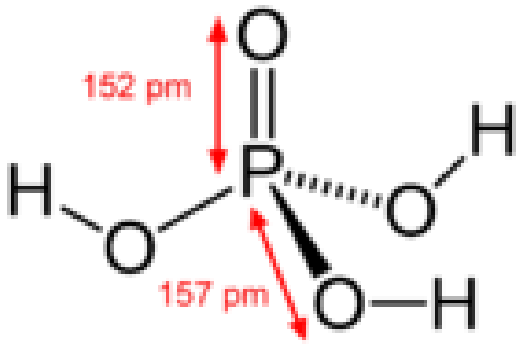
but the porosities in triturated cements are smaller and more uniform than hand mixed specimens.[28] Hence in this study GC Fuji II LC Capsule (Radiopaque Light cured Reinforced Glass ionomer restorative, GC Corporation, Tokyo, Japan) was used.

The surfaces of the prepared glass ionomer samples were polished with 200, 400, 600 grit silicon carbide papers in order to create a flat surface for treatment and bonding.[41]

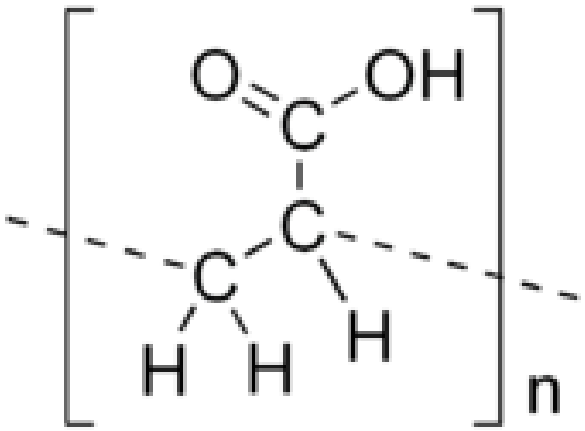
Arora et al has confirmed in an in vitro study that conditioning of GIC was necessary to improve its bonding with the composite resin. The matrix of the GIC gets dissolved in the acid leading to rough and porous surface, so that the bonding agent could easily penetrate into these irregularities and provide resin tags for bonding with the composite.[35]

Thus in the study four conditioners were used namely 35% phosphoric acid, 10% polyacrylic acid, 10% citric acid and 35% trichloroacetic acid was used to condition the surface of the resin modified glass ionomer cement to enhance it's bonding to resin composite.

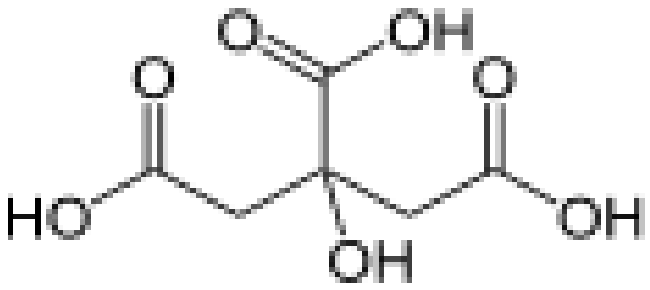
Phosphoric acid (also known as orthophosphoric acid) is a mineral (inorganic) acid having the chemical formula H_3PO_4. Orthophosphoric acid molecules can combine with themselves to form a variety of compounds which are also referred to as phosphoric acids, but in a more general way.



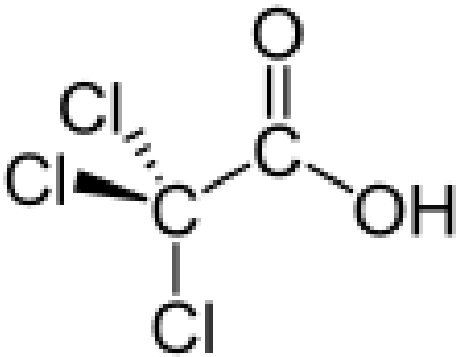
Polyacrylic acid (PAA or Carbomer) is generic name for synthetic high molecular weight polymers of acrylic acid. They may be homopolymers of acrylic acid, crosslinked with an allyl ether pentaerythritol, allyl ether of sucrose or allyl ether of propylene. In a water solution at neutral pH, PAA is an anionic polymer, i.e. many of the side chains of PAA will lose their protons and acquire a negative charge. This makes PAAs polyelectrolytes, with the ability to absorb and retain water and swell to many times their original volume.



Citric acid is a commodity chemical, and more than a million tonnes are produced every year by fermentation. It is used mainly as an acidifier, as a flavoring, and as a chelating agent. Citric acid has the formula $C_6H_8O_7$. It is a natural preservative/conservative which occurs naturally in citrus fruits and is also used to add an acidic or sour taste to foods and drinks. It consists of 3 carboxyl (R-COOH) groups.



Trichloroacetic acid (TCA; also known as trichloroethanoic acid) is an analogue of acetic acid in which the three hydrogen atoms of the methyl group have all been replaced by chlorine atoms. It is prepared by the reaction of chlorine with acetic acid in the presence of a suitable catalyst.



Pamir et al in an in vitro study proved that acid conditioning of glass ionomer was advocated to improve the bond strength between composite and glass ionomer. Application of 37% phosphoric acid over glass ionomer cement for 60 seconds increased the bond strength between glass ionomer and composite resin.[41]

In another study by Mitra et al the effect of phosphoric acid over glass ionomer was assessed. In the initial 5 seconds of application the gel matrix was dissolved leaving clusters of glass particles covered with gel matrix. Within 10 seconds surface porosities appeared which increase to void like spaces in 15 seconds. It is recommended not to condition the surface for more than 30 seconds. So in this study the surface conditioners are applied for time of 20 seconds[42].

The ten specimens of each of the groups was divided into seven for which adhesive and composites was placed and bond strength of the RMGIC to resin composite evaluated and the remaining three specimens were further analyzed by scanning electron microscopy to observe the conditioned surfaces.

The bonding agent used in this study was Adper single bond 2 (3M ESPE, Dental Products, St Paul, MN, USA), a total etch adhesive which shows better bond strength than self etch adhesive.[57] This was applied to seven specimens of all the groups and Filtek Z350 XT was placed in increments in the stainless steel molds and

light cured for 40 seconds using light curing unit (DENTSPLY, Milford, Detroit, USA).[54]

After storage period the specimens were tested in the shear mode in an universal testing machine. (Universal Testing Machine- Model 3345; Instroncorp, Canton, Mass, USA). A corresponding software was used to record the data. A knife head shearing rod with a cross head speed of 1mm/ minute was used to load the specimens until they fractured at the interface.

Out of 10 specimens the remaining three specimens were surface treated and evaluated under scanning electron microscope. After drying the specimens, it was placed in a gold sputtering machine and was examined under scanning electron microscope. Photomicrographs of each specimen were taken to evaluate the effect of conditioners.

The values obtained were tabulated and statistically analysed using computer software SPSS (16.0) version. The data was expressed in its mean and standard deviation. One way ANOVA was applied for statistical analysis. Post hoc followed by Dunnett's test was used to find the statistical significance between the groups. P value less than 0.05 was considered statistically significant at 95% confidence interval.

The highest mean bond strength value of 10.68 MPa was obtained with the group conditioned with 35% phosphoric acid. These findings of the study were in

accordance with previous study by Pamir et al where mean bond strength value of 10.0 MPa was obtained when conditioned with 35% phosphoric acid for 15 seconds.[41] In a study by Ismail et al, lower mean bond strength value of 4.47 MPa was obtained when conditioned with 37% phosphoric acid for 15 seconds. This is mainly attributed to the use of hand mixing of glass ionomers.[39] In a study by Otsuka et al, higher mean bond strength value of 14.7 MPa was obtained when conditioned with 35% phosphoric acid which is mainly attributed to the use of self etch adhesive in the study.[45]

SEM photomicrographs of 35% phosphoric acid treated specimens show the least salt crumps formation among other groups, indicating the milder the acid attack the salt crumps formation will be minimal. As a consequence of which unflushed ions such as Na+, Ca2+, Al3+will be available in sufficient amounts to effectively interact in a conducive medium (i.e. unset GIC) for available interactions with bonding agents.[40] Phosphoric acid with pH of 2 has the highest bond strength among the groups .

In the present study, the shear bond strength value of 9.10 MPa was obtained when the specimens were conditioned with 10% polyacrylic acid. According to Bortoletto et al enamel treated with 10% polyacrylic acid resulted in significant increase in bond strength.

The SEM Photomicrograph of 10% polyacrylic acid treated specimens showed salt crumps formation greater than group II a i.e. 35% phosphoric acid treated specimens. Observations coincide with the tested bond strength results where in 10% polyacrylic acid shows lower bond strength and greater crumps formation than 35% phosphoric acid specimens.

In this study a mean bond strength value of 7.19MPa was obtained in group conditioned with 10 % citric acid. In another in vitro study 10 % citric acid was used as enamel and dentin conditioner and proved effective in removing the smear layer.[60]

SEM Photomicrograph of 10% Citric Acid treated specimens with more salt crumps than both Group II a and Group III a i.e. 35% phosphoric acid and 10% polyacrylic acid treated specimens.

The use of 35% trichloroacetic acid as conditioner was used in this study to assess its effect on bond strength. In a study by Khoroushi et al, the application of 35% and 50% trichloroacetic acid on enamel surfaces showed an improved bond strength to resin composite similar to that obtained with 35% phosphoric acid.[37]

The application of 35% trichloroacetic acid on glass ionomer surface showed increased bond strength to resin composite when compared with the control group. Since trichloroacetic acid is an aggressive acid with a pH of 1.0, lower concentration of 35 % trichloroacetic acid was used in the study.[37]

SEM photomicrograph of 35% trichloroacetic acid treated specimens with maximum salt crump formation compared to Groups II a, III a, IV a. Maximum salt crumps formed with the minimum bond strength values.

The SEM results have demonstrated that 35% phosphoric acid with pH of 2 has least salt crumps and maximum salt crumps formation was seen in the SEM photomicrographs of Group V i.e 35% trichloroacetic acid with a pH of 1. Group I (control group) specimens showed the least bond strength in comparison with all the other groups as no surface treatment was done, which could enhance the adhesion of composite to RMGIC.[40] The presence of salt crumps indicates decreased bond strength as does the resultant bond strength values which co-relate with the SEM analysis.

There are not many studies in literature that have evaluated the effect of conditioners like polyacrylic acid, citric acid and trichloroacetic acid on glass ionomer surface and its bond strength to composite. Since this is an in vitro study, further clinical trials are needed to verify the results and observations of the effect of surface conditioners on glass ionomer surfaces in laminate restorations.

SUMMARY & CONCLUSION

Summary

The improved performance of resin composites and the desire for aesthetics has encouraged clinicians to use composite as the material of choice for posterior restorations as a possible alternative to amalgam. There are certain disadvantages of resin composites like polymerization shrinkage, associated microleakage, pulpal irritation and lack of anticariogenecity. Therefore sandwich restorations play a pivotal role in restorative dentistry where GIC is placed below composite restorations.

Glass-ionomer cement is known for its biomimetic properties, because of its similarity to the mechanical properties of dentine. This, along with the benefits of adhesion and release of fluoride, render it an ideal material in many restorative situations. But due to its reduced mechanical properties it should only be used as a final restorative material in low stress areas, and it must be protected by resin composite or amalgam in areas of high stress. Resin modified GIC has proved to be a material with improved properties and aesthetics as compared to the conventional glass ionomer. As there is always possibility of fracture at the resin – GIC interface, surface conditioners have been used to enhance the adhesion of the same. This is an in vitro experimental study to investigate the effect of four different conditioners on the shear bond strength of composite to resin modified glass ionomer.

A total of 50 Resin modified glass ionomer moulds were prepared in stainless steel molds (6 mm in diameter and 4mm in thickness). It was divided into five groups of 10 molds each, out of which 7 molds were used for testing bond strength and 3 for

Scanning electron microscope analysis. The various conditioners used were, phosphoric acid (35%), polyacrylic acid (10%), citric acid (10%), trichloroacetic acid (35%). Group I was negative control without any treatment. Group II, III, IV and V were treated with phosphoric acid (35%), polyacrylic acid (10%), citric acid (10%), trichloroacetic acid (35%) respectively. The three specimens, of each group for SEM analysis was done to analyse the surface after treatment with the four conditioners.

In the seven specimens of the groups for bond strength testing, stainless steel molds (4mm internal diameter and 4mm height) was prepared and placed on the glass ionomer surface. Finally Filtek Z350 XT (3M ESPE, USA) light cure composite was packed inside the prepared mold and light cured for 40 seconds. Statistical analysis was done by using SPSS (16.0) version. One way ANOVA (Post hoc test) followed by Dunnett's test used to find the statistical significance between the groups. P value less than 0.05 considered statistically significant at 95% confidence interval.

Results of the study have shown that group II specimens treated with 35% phosphoric acid showed the maximum bond strength followed by group III, group IV and group V. SEM analysis showed least salt crump formation in groups treated with 35% phosphoric acid and more salt crump formation in groups treated with 35 % trichloroacetic acid. This correlates with the bond strength result in which 35% phosphoric acid has the maximum bond strength among all the groups.

Conclusion

Within the limitations of the present study it can be concluded that surface conditioning with conditioners like 35% phosphoric acid, 10% polyacrylic acid, 10% citric acid and 35% trichloroacetic acid increased the bond between resin composite and resin modified GIC enabling better bonding thus ensuring better success of sandwich restorations.

FIGURES

FIG: 1 Light Cured Resin Modified Glass Ionomer Capsule

FIG 2: Applier with GIC Capsule

FIG 3: Glass ionomer discs prepared from stainless steel molds

FIG 4: Specimens Embedded in acrylic block

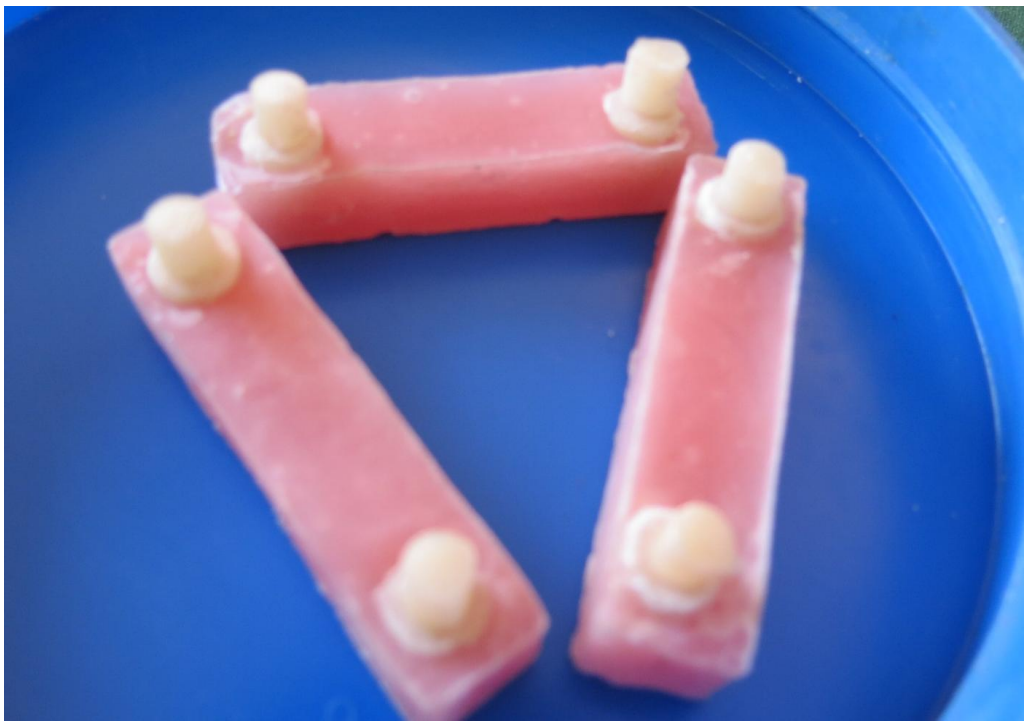


FIG 5: Materials Used in the Study

FIG 6: Shear bond strength testing

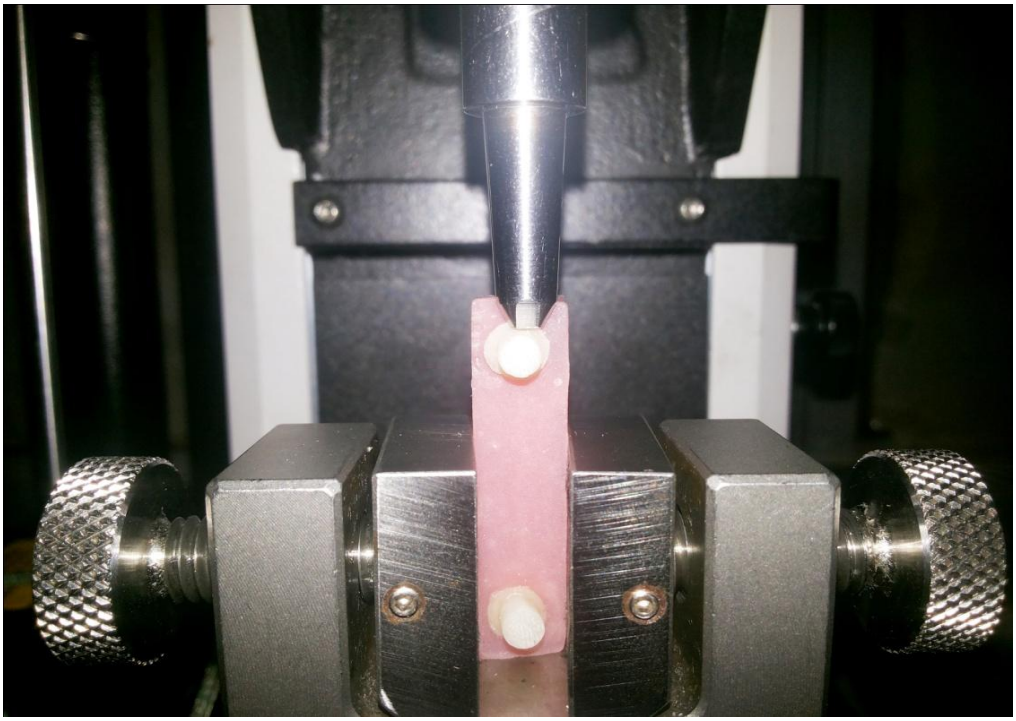


FIG 7: Gold Sputtering Machine

FIG 8 :Scanning Electron Microscope

FIG 9:Photomicrograph of Group II a (35% Phosphoric acid treated specimen)

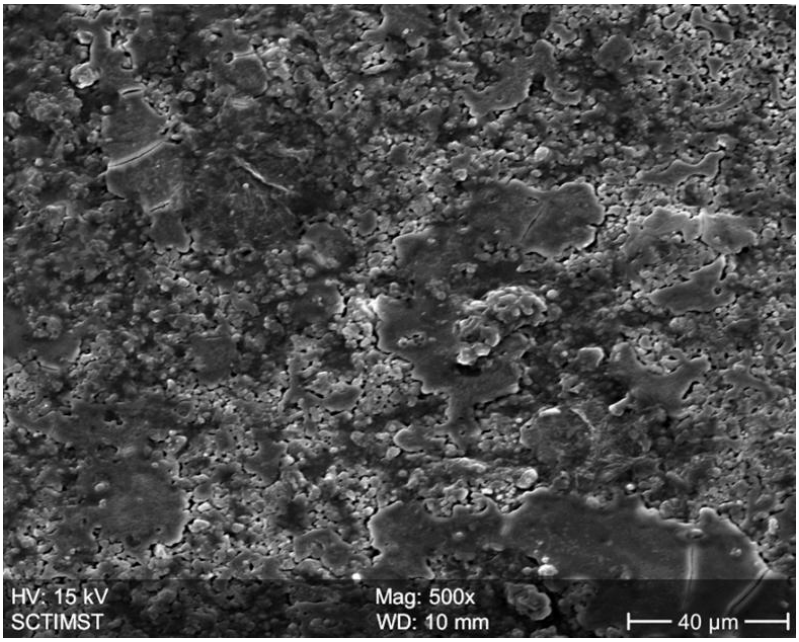


FIG 10:Photomicrograph of Group III a (10% Poly acrylic acid treated specimen)

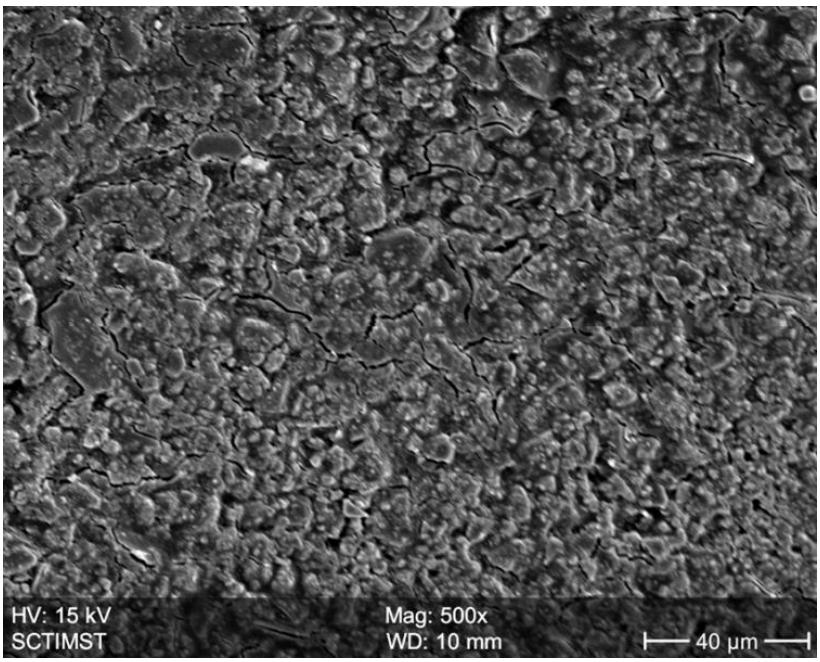


FIG 11:Photomicrograph of Group IV a (10% Citric acid treated specimen)

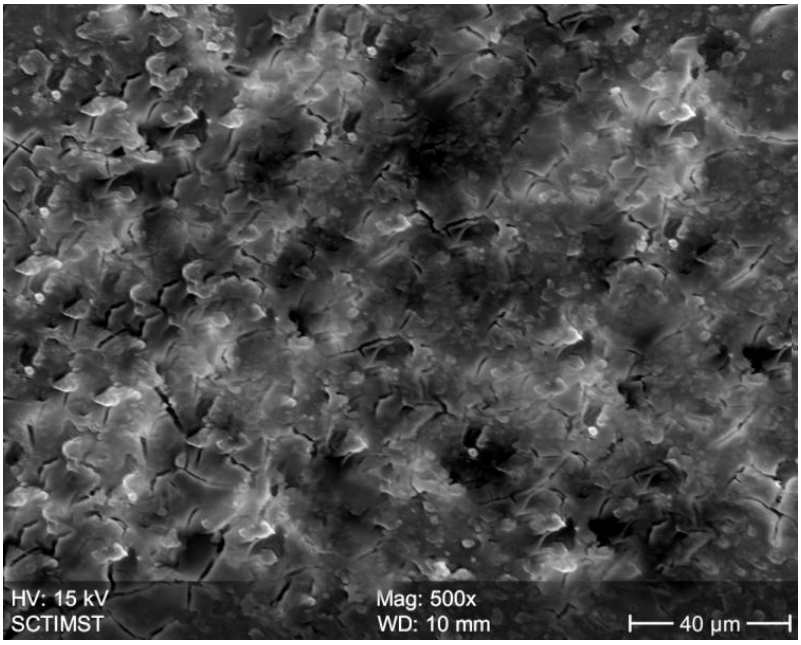


FIG 12: Photomicrograph of Group Va (35% trichloro acetic acid treated specimen)

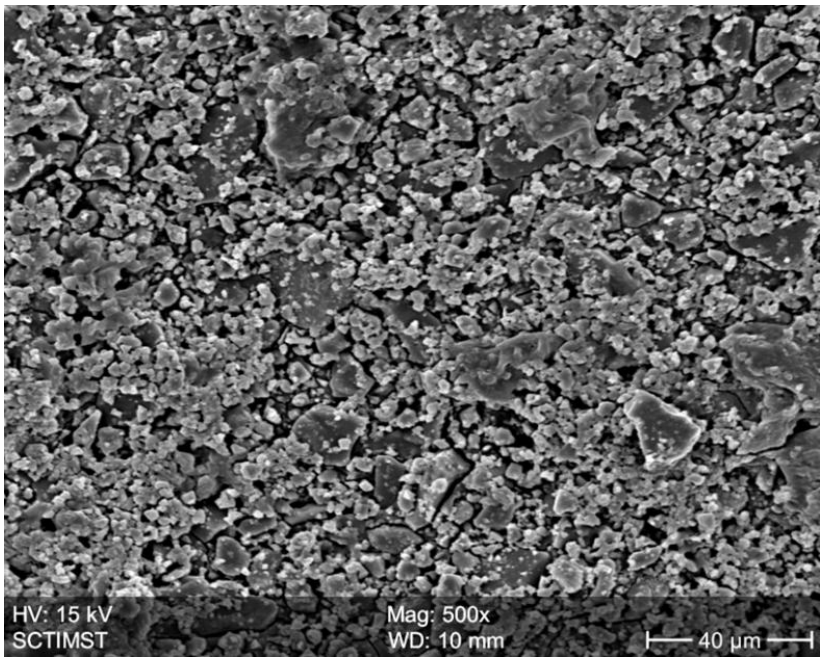
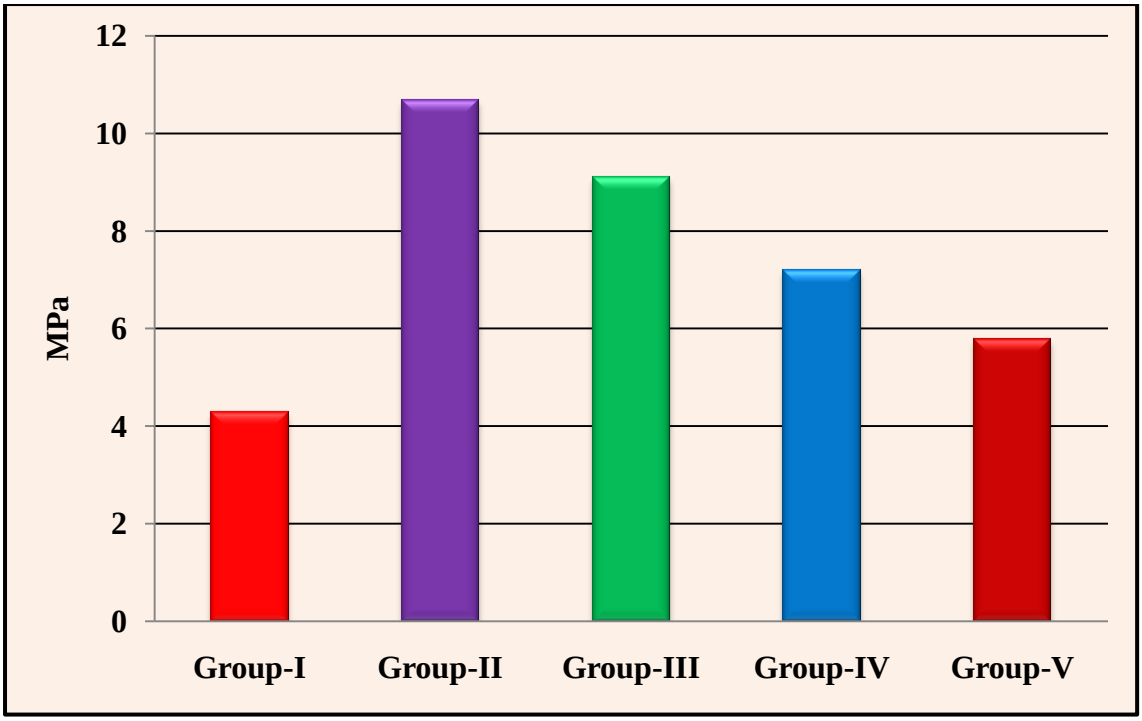


FIG 13: Mean Shear bong strength (MPa) values of different groups



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